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# Using The Selective Functional Movement Assessment And Regional Interdependence Theory To Guide Treatment Of An Athlete With Back Pain: A Case Report

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1 Using the Selective Functional Movement Assessment and  
2 Regional Interdependence Theory to Guide Treatment of an  
3 Athlete with Back Pain: A case report.

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15  
16 The patient signed an informed consent allowing the use of medical information and photos for  
17 this report and received information on the institution's policies regarding the Health Insurance  
18 Portability and Accountability Act.

19  
20  
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## ABSTRACT

**Background:** Despite the multidirectional quality of human movement, common measurement procedures used in physical therapy examination are often uni-planar and lack the functional complexities involved in daily activities. Currently, there is no widely accepted, validated standard to assess movement quality. The Selective Functional Movement Assessment (SFMA) is one possible system to objectively assess complex functional movements. This case report illustrates the application of the SFMA in the management of a patient with non-specific low back pain (LBP).

**Case Description:** An adolescent male athlete with non-specific LBP was evaluated using the SFMA. It was determined that the patient had mobility limitations remote to the site of pain (thoracic spine and hips) which therapists hypothesized were leading to compensatory hypermobility at the lumbar spine. Guided by the SFMA, initial interventions focused on local (lumbar) symptom management, progressing to remote mobility deficits, and then addressing the local stability deficit.

**Outcomes:** All movement patterns became functional/non-painful except the right upper extremity medial rotation-extension pattern which was still short of the standard upon discharge. At discharge, the patient demonstrated increased soft tissue extensibility of the hip musculature and joint mobility of the thoracic spine along with normalization of lumbopelvic motor control. Pain on a 0/10 scale improved from 3/10 at initial examination to a 0/10 at discharge.

**Discussion:** Developing and progressing a plan of care for an otherwise healthy and active adolescent with non-specific LBP can be challenging. Human movement is a collaborative effort of muscle groups that are interdependent; the use of a movement-based assessment model can help identify weak links affecting overall function. The SFMA helped guide therapists to dysfunctional movements not seen with more conventional examination procedures.

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## **BACKGROUND and PURPOSE**

Non-specific low back pain (LBP) is a challenging diagnosis for patients and healthcare professionals frequently seen in outpatient orthopedic settings. LBP is the most commonly reported musculoskeletal complaint among American adults with greater than 1 in 4 reporting symptoms in the previous three months.<sup>1</sup> Studies have shown that by age fifteen, the incidence of LBP was as high as 36% among adolescents and even more prevalent in those who played sports.<sup>2</sup> The majority of these cases lack an underlying diagnosis and are classified as non-specific LBP.<sup>3</sup> Certain prognostic factors have been consistently identified for many regional pain syndromes and include previous injury or reports of pain, multiple sites of pain and longer pain duration<sup>4</sup>. This supports the idea that one of the primary risks for injury is previous injury, which may be attributed to changes in kinematics and proprioception.<sup>5</sup>

Despite emphasis on movement and function in physical therapy (PT), our traditional examination and evaluation procedures tend to be heavily geared toward measurements of motion in a single plane or isolated strength of one muscle to identify an anatomical source of pain, lacking the qualitative evaluation of movement patterns as a whole. When looking at musculoskeletal examination, the APTA's Guide to Physical Therapy practice includes only gross range of motion and strength while lacking specific outcome measures of movement quality.<sup>6</sup> Gray Cook's Selective Functional Movement Assessment (SFMA) is a reliable movement-based diagnostic tool which provides clinicians with a standard to identify movement dysfunction in patients with known musculoskeletal injury.<sup>7</sup> This objective system assists the healthcare professional in applying a qualitative approach, in parallel with quantitative measurements, in order to guide treatment of musculoskeletal pain and associated movement

dysfunction using targeted interventions.<sup>8</sup> The SFMA is rooted in the theory of Regional Interdependence (RI) which views all regions of the body as being “musculoskeletally linked”.<sup>9</sup> According to the RI theory, seemingly unrelated impairments in remote regions may be the cause of a patient’s reports of pain but may go unidentified by evaluating isolated localized movements alone. The SFMA consists of a series of ten whole body functional movements designed to assess fundamental movement patterns in those with known musculoskeletal pain to help identify meaningful impairments seemingly unrelated to the primary complaint and guide development and implementation of an individualized plan of care (POC).

Patients with non-specific LBP are good candidates for being evaluated using the SFMA because they lack a clear diagnosis or clearly identified anatomic source for their pain. Research has shown that treatment plans for patients with chronic LBP which focus on a single pathological structure often result in poor outcomes.<sup>10</sup> The SFMA can guide the PT to underlying movement dysfunction in remote regions of the system that may be the cause of abnormal stress in the lumbar spine. Many studies have successfully linked limitations in remote regions to symptoms elsewhere in the system, including limitations of hip mobility to LBP and foot dysfunction causing patellofemoral pain.<sup>11-12</sup> These correlations suggest the need for a valid evaluative system capable of identifying these dysfunctions to improve outcomes and potentially decrease recurrence. The purpose of this case study was to explore the use of the SFMA to guide evaluation and treatment in a patient with chronic LBP and provide an example of its application as a framework for clinicians to use in future evaluation and treatment of patients.

## **CASE DESCRIPTION**

### **History**

The patient signed an informed consent to allow use of his personal medical information for this case report. The patient (IB) was an 18 year-old male who had just finished his first year of college and was referred to outpatient PT by his primary care provider. IB's chief complaint was intermittent low back pain for the last two years which had become worse in the last three months, with new onset of symptoms in the posterolateral left hip. IB was an avid weight lifter and participated on his college soccer team. At the time of evaluation he had decreased his lifting frequency from five days a week to two and had significantly adjusted his exercise routine due to his pain; he was still playing soccer 2-3 times a week. IB reported increased pain and stiffness following weight lifting and sports which was reduced with Ibuprofen and activity modifications. IB was independent in all daily activities despite some discomfort. IB reported his primary goal was to be pain-free with activity so he could return to his full pre-season lifting schedule and full participation in collegiate level soccer.

### **Systems Review**

The systems review revealed all systems were unimpaired except the musculoskeletal system. The patient demonstrated limited gross spine and hip range of motion (ROM) and slightly decreased strength in bilateral hips. (Table 1)

### **Clinical Impression 1**

IB's general complaints of LBP for two years and recent left hip pain could be the result of many possible diagnoses; however, he had not undergone any diagnostic imaging to rule potential diagnoses in or out. IB was referred to PT to identify and treat the source of his LBP using physical examination/special tests and measures. Based on history, it was suspected that IB

may have muscle imbalances in the lumbopelvic region leading to LBP with activity. IB was a good candidate for this case report due to the complexity of his LBP complaint and lack of a definitive diagnosis.

## **EXAMINATION**

### **Tests & Measures**

Prominent results from initial exam and discharge can be seen in table 2. Using a numeric pain rating scale, the patient reported his pain was a 7/10 at worst, 2/10 at best and a 3/10 at the time of examination.<sup>12</sup> IB was evaluated using the SFMA which revealed dysfunctional/non-painful movement (DN) in six of the ten patterns. Most prominently he was limited in the multi-segmental patterns, which suggested either trunk or hip mobility limitations. He was also limited in his cervical and upper extremity (UE) movement patterns as well as ability to perform a deep squat. A more detailed explanation of what these findings indicated and administration of the SFMA can be found in Appendix A. SFMA findings, along with patient history, guided subsequent tests and measures.

All special tests and measures were performed according to O'Sullivan and Magee.<sup>14-15</sup> To identify regional sources of the dysfunctional patterns, and whether they were due to mobility or stability issues, special tests for soft tissue extensibility of the hip were performed along with a joint mobility assessment of the spine. Special tests were positive for decreased soft tissue extensibility around the hip including the Modified Thomas Test, Patrick Test and 90/90 Straight Leg Raise Test. The Modified Thomas Test was graded as a pass/fail, based upon therapist assessment of whether the test-leg angle at the knee was greater or less than 90°. <sup>16</sup> Patrick's Test was used to determine involvement of the hip joint and/or a tight iliopsoas and was also positive for muscular tightness.<sup>14</sup> The 90/90 Straight Leg Raise Test was found to be positive for

decreased hamstring extensibility determined by a knee angle less than 125°. <sup>14</sup> Decreased joint mobility throughout the thoracic spine and ribs was noted by means of assessment using anterior-posterior glides. <sup>18</sup> Isometric break manual muscle tests of the hips were performed bilaterally and revealed asymmetrical strength with the right being slightly stronger than the left throughout all planes. This method of strength testing has been shown to be both reliable and valid. <sup>17</sup> Postural analysis revealed increased thoracic kyphosis and forward shoulders as well as a moderately increased anterior pelvic tilt and lumbar lordosis in standing. Excessive anterior pelvic tilt remained during gait analysis but gait was otherwise within normal limits. Functional gait analysis has been found to be moderately reliable. <sup>19</sup> Hip and sacroiliac (SI) joint pathologies were ruled out using the Hip Scouring Test and Gaenslen's Test, respectively. The Hip Scouring Test is a valid and reliable test to assess impingement or other pathology at the hip and Gaenslen's has been shown to be reliable based on multiple studies. <sup>14,20</sup> Additionally, SI joint misalignment and leg length discrepancy were ruled out by palpation, visual observation and supine measurement. <sup>14</sup> The Slump Test, which is valid and reliable for adverse neural tension, was negative. <sup>14</sup> Facet and disc pathology were ruled out using the Quadrant Test despite literature indicating its poor diagnostic accuracy. <sup>21</sup> Palpation revealed tenderness throughout the bilateral erector spinae, quadratus lumborum, gluteus maximus and medius.

## **Clinical Impression 2**

Examination findings confirmed the hypothesis that IB had functional movement pattern dysfunction contributing to his LBP. Based on predominant findings of decreased mobility in the hips, thoracic spine and shoulder girdle, therapists believed that as compensation for this lack of motion, the lumbar spine was moving excessively. His stability and mobility limitations were consistent with the joint-by-joint theory which argues that joints alternate in their primary role



from stability to mobility and when a joint isn't able to carry out their role, the next joint in the chain eventually will.<sup>8,22</sup> IB displayed limited mobility at the hips, thoracic spine and shoulder which, according to this theory, function primarily as mobile joints while the lumbar spine serves primarily as a stable junction between the thoracic spine and pelvis. Therapists hypothesized that dysfunctional movement in basic SFMA patterns indicated a poor fundamental foundation for proper movement, causing excessive compensation at the lumbar spine.

Dysfunctional patterns could be the result of a true mobility deficit stemming from either limited soft tissue extensibility or joint mobility, or due to increased tone as a result of an unstable segment.<sup>8</sup> Based on ROM testing in supported postures, it was clear the primary reason for decreased mobility at the hip was soft tissue extensibility limitations of surrounding musculature and the thoracic spine had limited ROM due to impaired gross vertebral joint mobility. Based on excessive anterior pelvic tilt and lack of lumbopelvic control while performing quadruped stability exercises, therapists believed there were also underlying core stability deficits. This may have resulted in his gross increase in tone as a means to restore stability. However, it was decided this was a secondary dysfunction that would be addressed at a later point once mobility had been restored.

Therapists also believed that a major contributor to limited UE ROM was restricted thoracic spine extension as the patient was only limited in the functional pattern and had full motion when the pattern was broken down into its individual parts. The working hypothesis was that these limitations had caused this patient to load his lumbar spine in a hyperextended and unstable position when weight training, resulting in excessive pressure.

## **Physical Therapy Diagnosis**

Based on findings from the examination, therapists determined IB's primary PT diagnosis was impaired joint mobility, motor function, muscle performance and range of motion associated with localized inflammation (pattern 4E) as well as a secondary diagnosis of impaired posture (pattern 4B). The ICD – 9 code was Lumbago (724.2).

## **Prognosis**

IB was a good candidate for PT due to his age, active lifestyle and motivation. In considering prognostic factors for recovery, chronicity was a negative factor, but the patient's young age was a positive factor.<sup>4</sup> With improved mobility, stabilization exercises, postural modification and corrected movement patterns, it was anticipated that IB's symptoms would subside, allowing him to meet his long-term goal of return to full activity with proper form and mechanics. Discharge criteria included being pain-free with at rest and with exercise and attainment of an accepted score on the Functional Movement Screen (FMS) indicating decreased risk of injury with return to activity.<sup>8, 24</sup>

## **INTERVENTIONS**

### **Coordination, communication, documentation**

Therapists communicated to IB that the POC was to alleviate symptoms first before progressing to mobility, then stability exercises.

### **Patient/client related instruction**

IB was educated on what therapists hypothesized was contributing to his LBP. Therapists suggested to the patient that he avoid activities which caused pain and highly recommended he reduce the number of soccer games he was playing while continuing to adjust his weight training

program. Finally, the patient was given an initial home exercise program (HEP) which included foam rolling for the hamstrings, quadriceps and thoracic spine, standing hamstring stretch, half kneeling rear foot elevated hip flexor stretch as well as spine flexion/extension in quadruped with diaphragmatic breathing. IB confirmed he understood the POC, HEP and discharge criteria.

## **Procedural interventions**

The patient was seen for 13 visits over nine weeks. Visits ranged from 45 minutes to one hour in duration and began with one to two visits per week initially, then one visit per week during the last three weeks. Interventions, based on the categories put forth by the Guide to Physical Therapist Practice, included manual therapy, motor function training, and therapeutic exercises.<sup>6</sup> Manual therapy techniques included soft tissue massage, spinal mobilization, high velocity manipulation of the spine, and passive ROM. Motor function training was incorporated into most exercises in the form of neuromuscular re-education for improved postural stabilization. Therapeutic exercises incorporated into the POC included flexibility, strength and power exercises, and breathing strategies.

Therapists initially prioritized pain relief in the initial one to three weeks, theorizing that pain would disrupt normal movement patterns and cause continued dysfunction.<sup>5</sup> This same rationale was applied to the decision to attain full ROM, which was the focus of weeks three to six, before performing stability exercises. Based on clinical experience therapists believed that attempting exercises with limited range would also result in altered movement patterns. Interventions carried out were from one of three categories put forth by Cook including “resets” to decrease pain or restore mobility, followed by “reinforcement” exercises to protect the reset gains, and finally “reloading” movements which would integrate new gains into a functional pattern using therapeutic exercise.<sup>8</sup> An example of this progression would be hamstring

stretching as a mobility “reset”, he would then perform toe touches with heels elevated to reinforce hamstring length and pattern a posterior weight shift, and finally his “reload”: a proper deadlift with adequate posterior weight shift of the pelvis to strengthen in the corrected movement pattern.

To begin every treatment session, the patient was assessed using the SFMA movements which were dysfunctional during the previous visit in order to guide treatment. Reports of pain were addressed with soft tissue massage, positioning and breathing techniques or spinal manipulation.<sup>25-27</sup> Limited motion or soft tissue extensibility was addressed with soft tissue massage and sustained stretching; joint mobility was treated with high velocity spinal manipulation or P-A glides of the vertebrae throughout the thoracic and lower cervical spine.

14,18,25,29

Once mobility was cleared, his limited lumbopelvic control with movement became more apparent. This was corrected with static stability exercises such as planks followed by dynamic core stability exercises which incorporated extremity movements while maintaining pelvic control.<sup>28</sup>. Stability exercises were progressed based on neurodevelopmental milestones beginning with a posture that provided maximal support, such as quadruped or ½ kneeling, and progressed to positions demanding more motor control and balance such as asymmetrical split-stance or single-leg stance. Therapists believed that if the patient could not display effective motor control in foundational positions, he likely would compensate in more complex patterns leading to continued stress on his back. Once IB demonstrated good control of his pelvis without excessive lumbar extension, his exercises in the final three weeks focused on return to weight lifting with proper form.

Initially IB's primary limitations were in the multi-segmental patterns for flexion, extension and rotation of the spine (Appendix B) These patterns were cleared for mobility and pain in the first five sessions using manual therapy techniques and as a result of the patient's commitment to his HEP. These gains were maintained for all subsequent visits and stability exercises were initiated. Despite these patterns being functional, IB continued to demonstrate excessive lumbar lordosis with advanced exercises. Focus was then shifted to UE movement patterns which were limited in the medial rotation and extension pattern, primarily on the right side. Based on clinical experience and the joint-by-joint theory it was hypothesized that this limited motion was causing the patient to compensate with excessive lumbar extension when under a barbell.<sup>8,22</sup> Shoulder ROM improved in subsequent treatment sessions, and combined with core stabilizing neuromuscular-reeducation exercises, corrected this compensation during Olympic lifts.

At that time, IB was sent home to progress his activity over two weeks, then return for a reevaluation. At that time, IB reported being pain-free with activity and was assessed using the FMS (Table 3). The patient met his long-term goal of pain-free weight lifting as well as the therapist's criteria for discharge based on FMS scoring and was discharged with an updated HEP after ensuring proper technique with deadlift and squat.

## **OUTCOMES**

IB showed significant improvement in ROM, strength, motor control and pain level and met his long-term goal of a full pain-free return to weight lifting and soccer. Additionally, he met both long-term goals set forth by therapists which included 5/5 symmetrical strength in bilateral hips and an FMS score  $\geq 14$  with no asymmetries or 0's. Thoracic spine joint mobility (T1 – T12) went from a 2/6 to a 3/6 based on a P-A glide assessment and hip mobility improved

bilaterally based on special tests. IB received a designation of DN on nine of the ten SFMA movement patterns at initial evaluation and only one (right UE pattern) at discharge. Most notably, IB reported 0/10 pain at discharge, improved from 7/10 at initial examination. IB demonstrated improved form with deadlifting, with proper control of his pelvis and lumbar lordosis. Outcomes at initial examination and discharge are detailed in Tables 2 and 3

## **DISCUSSION**

This case study outlines the application of the SFMA and theories of RI to guide initial examination, POC development, exercise selection and discharge criteria for a patient with LBP. Guided by the SFMA, this patient made significant improvements over the course of his nine week episode of care which allowed him to return to sports and weight lifting without pain. Emphasis placed on regaining mobility in his hips, mostly through his commitment to the HEP, appeared to be a major contributing factor to his decrease in symptoms. This further supports the previously noted relationship between hip ROM restrictions and LBP.<sup>11</sup> Once hip mobility was restored, emphasis was placed upon motor control to maintain stability at the lumbopelvic junction, which therapists believed may have been artificially created by the increased tone in his hips and thoracic spine as opposed to a true active stability. As Cook explains, we often assume limited hip motion causes back pain, but instability in the back may in fact have created the hip tightness as a “secondary brace” to continue functioning even if it reduces mobility. This works in conjunction with the joint-by-joint theory, wherein a possible instability at the lumbar spine may have created compensatory stability through increased tone at the joints above and below. It is difficult to determine which came first; therefore it was necessary to focus on maintaining a stable spine once mobility was restored.

Our primary hypothesis was that improved motor control and core stability in addition to the patient's newly acquired functional mobility, would allow him to return to athletics without risk of re-injury. To accomplish this, we sought to establish "basic functional movement patterns which lay the foundation for higher movement skills"<sup>8</sup> such as weight lifting and soccer. The goal of targeting movement pattern interventions was to attempt to resolve total body impairments, such as those identified by the SFMA. The SFMA guided therapists away from the tendency to treat one pathological structure in the back, and instead identified non-painful impairments in regions adjacent to the site of pain which required intervention. We believe that this approach may help avoid falling into a continued cycle of recurring and chronic pain by identifying the cause of pain rather than dealing with local symptoms.

This case study demonstrated that the use of the SFMA as a standard to qualitatively analyze movement at initial examination and throughout treatment can have positive outcomes when treating a patient with non-specific LBP. The SFMA and FMS provide a means to both assess painful movement and screen pain-free movement for injury risk, respectively. The system as a whole identifies subtle impairments in movement patterns of the active individual, theoretically resulting in decreased recurrence of injury. Currently only one study has looked at psychometric properties of the SFMA and it demonstrated poor to good reliability among novice evaluators and very good reliability in experienced users.<sup>7</sup> However, responsiveness to change and validity of the SFMA has yet to be explored. It would be beneficial to continue to investigate the application of the SFMA and associated outcomes in various musculoskeletal injuries. Validation of the SFMA as a clinical outcome tool has the potential to improve upon our current medical/pathoanatomic examination model, and to fill the current void as a widely accepted standard for the assessment of functional movement patterns.





## REFERENCES

1. Deyo RA, Mirza SK, Martin BI. Back pain prevalence and visit rates: estimates from U.S. national surveys, 2002. *Spine*. 2006; 31(23): 2724 – 2727.
2. De Luigi AJ. Low back pain in the adolescent athlete. *Phys Med and Rehabil Clin N Am*. 2014 ;25(4):763-88
3. Bhatia NN, Chow G, Timon SJ, et al. Diagnostic modalities for the evaluation of pediatric back pain: a prospective study. *J Pediatr Orthop*. 2008; (2): 230 – 233.
4. Mallen CD, Peat G, Thomas E, et al. Prognostic Factors for Musculoskeletal Pain in Primary Care: a systematic review. *Br J Gen Pract*. 2007; 57(541): 655–661.
5. Fulton J, Wright K, Kelly M, et al. Injury risk is altered by previous injury: A systematic review of the literature and presentation of causative neuromuscular factors. *Int J Sports Phys Ther*. 2014; 9(5): 583 – 595.
6. Guide to Physical Therapist Practice 3.0. *American Physical Therapy Association*. <<http://guidetoptpractice.apta.org/>>
7. Glaws KR, Juneau CM, Becker LC, et al. Intra- and inter-rater reliability of the Selective Functional Movement Assessment (SFMA). *Int J Sports Phys Ther*. 2014; 9(2): 195 – 207.
8. Cook G. *Movement*. California: On Target Publications; 2010.
9. Sueki DG, Cleland JA, Wainner RS. A regional interdependence model of musculoskeletal dysfunction: research, mechanisms, and clinical implications. *J Man Manip Ther*. 2013; 21(2):90-102.
10. Van Tulder MW, Koes BW, Bouter LM. Conservative treatment of acute and chronic nonspecific low back pain: A systematic review of randomized controlled trials of the most common interventions. *Spine*. 1997; 22(18): 2128 – 2156.
11. Mellin G. Correlations of hip mobility with degree of back pain and lumbar spinal mobility in chronic low-back pain patients. *Spine*. 1988; 13(6): 668 – 670.
12. Molgaard C, Rathleff MS, Simonsen O. Patellofemoral pain syndrome and its association with hip, ankle and foot function in 16 to 18 year-old high school students: a single-blind case-control study. *J Am Podiatr Med Assoc*. 2011; 101(3): 215 – 222.
13. Williamson A, Hoggart B. Pain: a review of three commonly used pain rating scales. *J Clin Nurs*. 2005; 14(7): 798-804.
14. Magee, David J. *Orthopedic Physical Assessment, 5<sup>th</sup> Edition*. Missouri: Saunders Elsevier; 2008.
15. O’Sullivan, Susan B. & Schmitz, Thomas J. *Physical Rehabilitation, 5<sup>th</sup> Edition*. Philadelphia: F.A. Davis Company; 2007.
16. Peeler JD, Anderson JE. Reliability limits of the Modified Thomas Test for assessing rectus femoris muscle flexibility about the knee joint. *J Athl Train*. 2008; 43(5): 470 – 476.
17. Cuthbert SC, Goodheart GJ. On the reliability and validity of manual muscle testing: a literature review. *Chiropr Osteopat*. 2007; 15: 4
18. Kaltenborn, FM. *Manual Mobilization of the Joints: Joint Examination and Basic Treatment. Volume II, The Spine*. Oslo, Norway: Norli; Minneapolis, Minnesota; 2012

19. Krebs DE, Edelstein JE, Fishman S. Reliability of observational kinematic gait analysis. *Phys Ther.* 1985; 65(7): 1027 – 1033.
20. Cattley P, Winyard J, Trevaskis J, et al. Validity and reliability of clinical tests of the sacroiliac joint. A review of the literature. *Australas Chiropr Osteopathy.* 2002; 10 (2): 73 – 80.
21. Stuber K, Lerede C, Kristmanson K, et al. The diagnostic accuracy of the Kemp’s test: a systematic review. *J Can Chiropr Assoc.* 2014; 58(3): 258 – 267.
22. Boyle M. *Advances in Functional Training.* California: On Target Publications; 2011.
23. Jeffries, L.J, et al. Epidemiology of Adolescent Spinal Pain: a systematic overview of the research literature. *Spine.* 2007; 32(23): 2630 – 2637.
24. Kiesel K, Plisky PJ, Voight ML. Can serious injury in professional football be predicted by a preseason Functional Movement Screen? *N Am J Sports Phys Ther.* 2007; 2(3): 147 – 158.
25. Bronfort G, Haas M, Evans RL, et al. Efficacy of spinal manipulation and mobilization for low back pain and neck pain: a systematic review and best evidence synthesis. *Spine J.* 2004; 4(3):335-56.
26. Janssens L, McConnell A.K, Pijnenburg M, et al. Inspiratory muscle training affects proprioceptive use and low back pain. *Med Sci Sports Exerc.* 2015; 47(1):12-9.
27. Kolar P, Sulc J, Kyncl M, et al. Postural function of the diaphragm in persons with and without chronic low back pain. *J Orthop Sports Phys Ther.* 2012; 42(4):352-62
28. Javadian, Y, et al. The effects of stabilizing exercises on pain and disability of patients with lumbar segmental instability. *Journal of Back and Musculoskeletal Rehabilitation.* 2012; 25(3):149-55.
29. Bervoets DC, Luijsterburg PA, Alessie JJ, et al. Massage therapy has short-term benefits for people with common musculoskeletal disorders compared to no treatment: a systematic review. *J Physiother.* 2015; 61(3): 106 – 16.

## TABLES AND FIGURES

**Table 1: Results of systems review at initial examination**

Cardiovascular/Pulmonary	
Not Impaired	Heart Rate: 76 beats/min
	Respiratory Rate: 12 breaths/min
Integumentary	
Not Impaired	No presence of scar
	Skin color and texture within normal limits
Affect, Cognition, Learning Style, Communication	
Not Impaired	Alert and oriented times 3
	Requests pictures for home exercise program
	English speaking, college educated
Neuromuscular	
Not Impaired	Transfers, locomotion, balance, coordination all within normal limits.
Musculoskeletal	
Impaired	Hip Strength: 4/5 on L and 4+/5 on R in all planes
	Spinal AROM: 25% limited/painful in all planes
	All other uni-planar ROM within normal limits all planes

**L** = left; **R** = right; **AROM** = active range of motion; **ROM** = range of motion; **SFMA** = Selective Functional Movement Assessment

**Table 2: Results of SFMA and other special tests at initial examination and discharge**

	Initial Evaluation Results			Discharge Results		
Selective Functional Movement Assessment (SFMA)		Left	Right		Left	Right
	Cervical Flexion	FN		Cervical Flexion	FN	
	Cervical Extension	FN		Cervical Extension	FN	
	Cervical Rotation	DN	DN	Cervical Rotation	FN	FN
	Upper Extremity (LRA)	FN	FN	Upper Extremity (LRA)	FN	FN
	Upper Extremity (MRE)	DN	DN	Upper Extremity (MRE)	FN	DN
	MSF	DN		MSF	FN	
	MSE	DN		MSE	FN	
	MSR	DN	DN	MSR	FN	FN
	Single Leg Stance	FN	FN	Single Leg Stance	FN	FN
	Deep Squat	DN		Deep Squat	FN	
Joint Mobility	- Thoracic Spine (all levels): 2/6 - Ribs: 2/6			- Thoracic Spine (all levels): 3/6 - Ribs: 3/6		
Numeric Pain Rating Scale	- Best: 2/10 - Worst: 7/10 - Current: 3/10			- Best: 0/10 - Worst: 2/10 (2 weeks prior) - Current: 0/10		
Modified Thomas Test	(+)			(-)		
Patrick Test (FABER)	(+)			(-)		
90/90 Straight Leg Raise Test	(+)			(-)		
Gaenslen's Test	(-)			(-)		
Hip Scouring Test	(-)			(-)		
Slump Test	(-)			(-)		
Quadrant Test	(-)			(-)		

**FN** = Functional/Non-painful; **DN** = Dysfunctional/Non-Painful; **LRA** = Lateral Rotation/Abduction; **MRE** = Medial Rotation/Extension; **MSF** = Multi-segmental Flexion; **MSE** = Multi-segmental Extension; **MSR** = Multi-segmental Rotation

**Table 3: Results of the Functional Movement Screen performed at discharge. The patient reached the long term goal of a 14 or higher with no 1's, 0's or asymmetries.**

Functional Movement Screen			
Screen	Raw Score (R)	Raw Score (L)	Final Score
Deep Squat	2	2	2
Hurdle Step	2	2	2
In-line Lunge	2	2	2
Shoulder Mobility	2	2	2
Shoulder Clearing Test	Negative	Negative	-
Active Straight Leg Raise	2	2	2
Trunk Stability Push-up	3	3	3
Push-Up Clearing Test	Negative	Negative	-
Rotary Stability	2	2	2
Posterior Rocking Test	Negative	Negative	-
Total			<b>15</b>

**Figure 1: Medial Rotation – Extension Stretch (left). Deadlift with neutral spine.**



426 **Figure 2: Multi-segmental flexion (left) and multi-segmental extension were functional/non-**  
427 **painful at discharge.**



428  
429 **Figure 3: Medial Rotation – Extension pattern was functional on the left but remained**  
430 **dysfunctional on the right at discharge.**



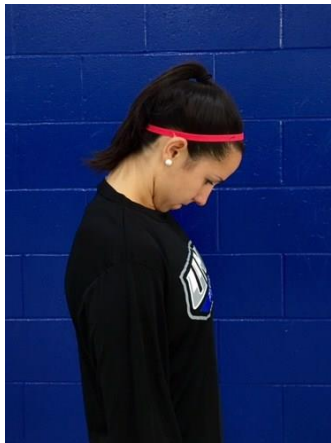


## Appendix A: SFMA Instructions, Patterns & Criteria

- The SFMA is not a predictor of risk like the FMS, but is an assessment to gauge the status of movement-pattern related pain.
- The SFMA is meant to be used for a patient with pain, unlike the FMS which is a pain-free screen. It uses movement to provoke symptoms and demonstrate dysfunction.
- The assessment consists of ten basic movements that are standardized for classification. Patterns are broken down into respective “breakouts” for clarity and perspective.
- When performing the assessment the examiner should avoid excessive instructions for form in order to evaluate how the patient moves naturally.
- Any additional movements deemed to be compensation outside the specified movement pattern is graded as dysfunctional.
- Any movement pattern that results in labored breathing is graded as dysfunctional.
- Any movements that provoke pain should be further assessed with caution as pain is known to alter motor control. Pain modulating therapies/modalities should be used and movements reassessed.
- Dr. James Cyriax use of the terms “strong” and “weak” to classify contractile tissues is replaced with function and dysfunction which better demonstrates lack of mobility, stability or symmetry in a given movement. Movements are graded with 4 possible notations based on subjective assessment:
  1. **Functional/Non-painful (FN)** – meets specified criteria and patient reports no pain
    - Further investigation of that pattern not recommended
    - Consider using FMS to assess pain-free functional movement patterns
  2. **Functional/Painful (FP)** – meets specified criteria but patient reports pain
    - Confirmation of patterns which can provoke pain can be used as a marker
    - Pattern can be broken down to sub-movements; proceed to treat symptoms
  3. **Dysfunctional/Non-painful (DN)** – does not meet criteria but patient reports no pain
    - Breakdown movement uncomplicated by pain
    - Further examine using breakout algorithm for that pattern to identify if the dysfunction is due to mobility or stability and whether the limitations stem from soft tissue extensibility or joint mobility
  4. **Dysfunctional/Painful (DP)** – does not meet criteria and patient also reports pain
    - Need to determine if poor movement is causing pain or pain is causing poor movement
    - Treat symptoms first before addressing movement with exercises

## Cervical Patterns

### Cervical Flexion



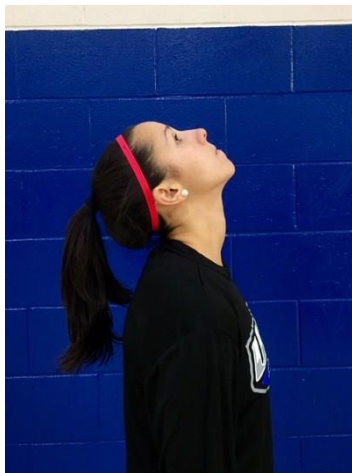
**Instructions:** Stand erect with feet together, toes pointing forward. Touch chin to chest with mouth closed.

**Criteria:**

1. Chin touches sternum with mouth closed

**Evaluating:** available cervical flexion including occipital-axis mobility

### Cervical Extension



**Instructions:** Stand erect with feet together, toes pointing forward. Patient instructed to extend neck back as far as they can.

**Criteria:**

1. Head reaches  $> 10^\circ$  of parallel

**Evaluating:** available cervical spine extension

### Cervical Rotation (R + L)



**Instructions:** Stand erect with feet together, toes pointing forward. Patient rotates the head as far as possible, then flexes the neck moving chin to collarbone.

**Criteria:**

1. Chin touches mid-clavicle

**Evaluating:** amount of available cervical spine rotation and lateral flexion in a pattern which combines both movements.



## Upper Extremity Patterns

### Medial Rotation-Extension (MRE) Pattern (R + L)



**Instructions:** Stand erect with feet together, toes pointing forward. Reach back and up spine with arm to try and touch opposite shoulder blade.

**Criteria:**

1. Touches inferior angle of contralateral scapula

**Evaluating:** internal rotation, extension and adduction of shoulder complex

### Lateral Rotation – Abduction (LRA) Pattern (R + L)



**Instructions:** Stand erect with feet together, toes pointing forward. Reach behind head and down spine to touch opposite shoulder blade.

**Criteria:**

1. Touches spine of contralateral scapula

**Evaluating:** external rotation, flexion and abduction of the shoulder

## Multi-Segmental Patterns

### Multi-segmental Flexion (MSF)



**Instructions:** Stand erect with feet together, toes pointing forward. Bend forward to touch toes and come back to standing.

**Criteria:**

1. Touches toes and returns to standing position
2. Sacral angle is  $\geq 70^\circ$
3. Presence of posterior weight shift (T-L junction over foot)
4. Uniform spinal curves

**Evaluating:** flexion of the hip and spine

### Multi-segmental Extension (MSE)



**Instructions:** Stand erect with feet together, toes pointing forward. Patient extends arms overhead with elbows in line with ears and bends backwards as far as possible.

**Criteria:**

1. ASIS clears toes
2. Maintains normal shoulder flexion ( $\geq 170^\circ$ )
3. Spine of scapula clears heels
4. Uniform spinal curves

**Evaluating:** extension of shoulders hips and spine

### Multi-segmental Rotation (MSR) – (R+ L)



**Instructions:** Stand erect with feet together, toes pointing forward. Rotate entire body as far as possible (hips, shoulders and head)

**Criteria:**

1. Pelvis rotation  $\geq 50^\circ$
2. Trunk/Shoulder rotation  $\geq 50^\circ$
3. No deviation of spine and pelvis
4. Limited knee flexion needed to achieve motion

**Evaluating:** rotational mobility of neck, trunk, pelvis, hips, knees and feet

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## Single Leg Stance (R + L)



**Instructions:** Stand erect with feet together then lift knee to hip and hold for 10 seconds.

**Criteria:**

1. Maintains for 10 seconds
2. No loss of height (bending of knee)

**Evaluating:** ability to stabilize independently on each leg

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## Overhead Squat



**Instructions:** Stand feet shoulder width apart with feet pointed forward. Raise arms over head and squat as deep as possible keeping heels on floor and hands over head.

**Criteria:**

1. Maintains shoulder flexion
2. Maintains neutral thoracic spine (no flexion)
3. Femur > than parallel to floor
4. No sagittal plane deviation of lower extremities

**Evaluating:** bilateral symmetrical mobility of the hips, knees, ankles and shoulders as well as thoracic spine extension.

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511 **Appendix B: Interventions**

	Interventions						
<b><u>Rx Day 1(exam)</u></b>	High velocity manipulation of T-spine in prone (T2 – T8)	Foam Rolling: quadriceps, hamstrings, hip flexors, glutes (1 minute each)	Standing rear foot elevated hip flexor stretch (2 x 1 min hold B/L)	Standing hamstring stretch in doorway (10 X 15 second hold B/L)			
<b><u>Rx Day 2</u></b> DN: MSF, MSE, MSR, B/L cervical rotation, B/L MRE, deep squat	STM erector spinae, multifidi, thoracic-lumbar (T-L) junction	Manual Contract-relax hamstring stretching ( 2 x 5 B/L)	Standing rear foot elevated hip flexor stretch (2 x 1 min hold B/L)	High velocity manipulation of T-spine in prone (T2 – T8)	Rear foot elevated MSF (1x10) Forefoot elevated MSE (1x10)		
<b><u>Rx Day 3</u></b> DN: MSF, MSE, MSR, B/L cervical rotation, B/L MRE, deep squat	STM erector spinae, T-L junction, posterior rotator cuff	Supine rib rolling/thoracic rotation stretch (1x10 with 10 second hold (B/L)	✓	✓	Thoracic and lumbar P-A glides (T1 – L3)	Banded MRE stretch in standing (10 X 15 second hold R)	
<b><u>Rx Day 4</u></b> DN: MSF, MSE, MSR, B/L cervical rotation, B/L MRE, deep squat	STM erector spinae, posterior rotator cuff	Thoracic and lumbar P-A glides (T1 – L3)	Banded MRE stretch in standing (10 X 15 second hold R)	½ kneeling hip flexor stretch with anterior band pull (2 x 1 min hold B/L)	Manual Contract-relax hamstring stretching ( 2 x 5 B/L)	Rear foot elevated MSF (1x10) (MSF cleared) Forefoot elevated MSE (1x10) (MSE cleared)	TRX walkout shoulder extension (10 x 10 second hold)
<b><u>Rx Day 5</u></b> DN: MSF, MSE, B/L cervical rotation, R MRE, deep squat	½ kneeling hip flexor stretch with anterior band pull (2 x 1 min hold B/L)	Self contract-relax hamstring stretch with band ( 2 x 5 B/L)	Rear foot elevated MSF (1x10) (MSF cleared) Forefoot elevated MSE (1x10)	Squats to 18” bench (2 x 10)	Planks (3 x 30 seconds)	Cat-camel pelvic rotation in quadruped (1x10) Bird-dogs (2x10 B/L)	Posterior weight shift into stability ball in quadruped (1x10)

			(MSE cleared)				
<u><b>Rx Day 6</b></u>  <b>DN:</b> B/L cervical rotation, R MRE, deep squat	✓	✓	✓	Planks (3 x 30 seconds)	½ kneeling diagonal lifts with Cook band (2 x 10 B/L)	Squats to bench (3x10)	RNT banded squats with anterior pull at knee (2 x 10)
<u><b>Rx Day 7</b></u>  <b>DN:</b> B/L cervical rotation, R MRE	STM posterior rotator cuff and pec minor	Banded MRE stretch in standing (10 X 15 second hold R)	TRX walkout shoulder extension (10 x 10 second hold)	Medial shoulder rotation mobility in extension with dowel (10 x 3 second hold)	Goblet Squats to 18" bench with 12kg kettlebell (3 x 10)	Posterior weight shift patterning with dowel (2 x 10)	Deadlift latissimus activation with barbell (1x5) Kettlebell deadlifts from 6" box 16kg (3 x 8)
<u><b>Rx Day 8</b></u>  <b>DN:</b> R MRE	Self soft tissue massage to posterior rotator cuff and pec minor with lacrosse ball	Horizontal shoulder adduction stretch (5 x 15 second hold)	Banded MRE stretch in standing (10 X 15 second hold R)	✓	✓	½ kneeling rhythmic stabilization (2 x 10 B/L)	½ kneeling diagonal lifts and chops with Cook band (2x10 B/L)
<u><b>Rx Day 9</b></u>  <b>DN:</b> R MRE	STM posterior rotator cuff and pec minor	High velocity manipulation of T-spine (T2 – T8)	✓	Barbell squats with 75 lbs (3 x 8)	Sled push with core activation with 90 lbs (4 x 100 ft)	Split squats (3 x 8 B/L)	Barbell deadlifts with 115 lbs (3x6)
<u><b>Rx Day 10</b></u>  <b>DN:</b> R MRE	Banded MRE stretch in standing (10 X 15 second hold R)	TRX walkout shoulder extension (10 x 10 second hold)	Medial shoulder rotation mobility in extension with dowel (10 x 3 second hold)	Single leg squats to 18" bench (3x8)	Barbell deadlifts with 115 lbs (3x6)	Single leg dead lift patterning with dowel (1x10)	Single leg dead lift to 6" box with 12kg kettlebell (3x6)
<u><b>Rx Day 11</b></u>  <b>DN:</b> R MRE	✓	✓	STM pec minor and posterior rotator cuff	Horizontal shoulder adduction stretch (5 x 15 second)	Sled push with core activation with 90 lbs (4 x 100 ft)	Single leg dead lift to 6" box with 12kg kettlebell (3x8)	Single leg squats to 18" bench (3x10)

				<i>hold)</i>			
<b>Rx Day 12</b> DN: R MRE, B/L cervical rotation	STM scalene and upper trapezius	High velocity manipulation of T-spine (T2 – T8)	Barbell shoulder extension stretch (2 x 6 for 5 second hold)	Core engage plank walkouts (2 x 10)	Squat Review		
<b>Rx Day 13</b> DN: R MRE	FMS Screen	HEP review					

512 **Key:** STM = soft tissue massage; P-A = posterior-anterior; R = right, L = left, B/L = bilateral  
513 SFMA = Selective Functional Movement Assessment; DN = dysfunctional/non-painful; MSF =  
514 multi-segmental flexion, MSE = multi-segmental extension, MSR = multi-segmental rotation,  
515 MRE = medial rotation extension; ✓ = repeat of exercise above